

# A New Species of *Nautilus* from Palau

BY

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(3 Plates; 2 Text figures)

## INTRODUCTION

IN 1976, THE DISCOVERY OF *Nautilus* living in deep water outside the fringing reef of Palau, Western Caroline Islands, was briefly highlighted in National Geographic Magazine (DUGDALE & FAULKNER, 1976). The Palauan *Nautilus* have subsequently been the focus of investigations of anatomy, ecology, movement and distribution, involving trapping, study and release of more than 1100 live animals (SAUNDERS, 1981, SAUNDERS *et al.*, 1978; SAUNDERS & SPINOSA, 1978, 1979). Although a considerable body of data concerning the Palauan *Nautilus* has been assembled, precise taxonomic status of this form has been uncertain; it has been variously identified as *Nautilus pompilius* Linnaeus, 1758; *N. cf. pompilius*, and *N. repertus* Iredale, 1944. Systematic comparison of this form with other recognized species of *Nautilus* indicates that the Palauan form deserves separate taxonomic designation; it is here described as a new species, *Nautilus belauensis*.

CEPHALOPODA Cuvier, 1798

ECTOCOCHLIA Schwartz, 1894

NAUTILOIDEA Hyatt in Zittel, 1900

NAUTILIDAE de Blainville, 1835

*Nautilus* Linnaeus, 1758*Nautilus belauensis* Saunders, spec. nov.

(Figures 2a, 3-14; Tables 1, 2)

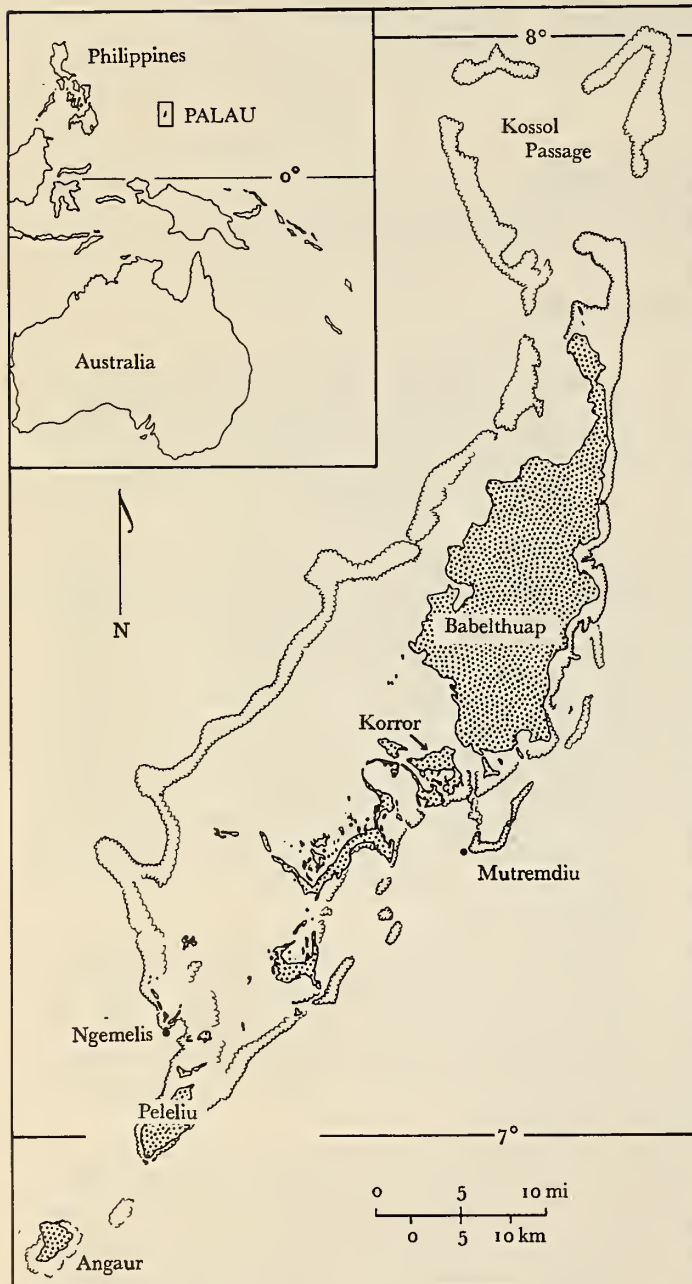
*Nautilus* sp. Dugdale & Faulkner, 1976.*Nautilus repertus* Iredale, 1944. FAULKNER, 1977; SAUNDERS & WEHMAN, 1977: 86.*Nautilus pompilius* Linnaeus, 1758. FAULKNER, 1976: pls. 118, 119; SAUNDERS & WARD, 1979; CARLSON, 1979.*Nautilus cf. N. pompilius* Linnaeus, 1758. SAUNDERS, SPINOSA, TEICHERT & BANKS, 1978: plt 9, figs. 7, 8; plt. 10, fig. 16; text-fig. 6; SAUNDERS & SPINOSA, 1978: figs. 1-11; SAUNDERS & SPINOSA, 1979.

**Diagnosis.** A species of *Nautilus* similar to *N. pompilius*, but distinguished by its large mature size (mean shell diameter approx. 200 mm), longitudinally crenulate growth lines on the shell and by the wide central radular teeth.

**Description.** Definition of *Nautilus belauensis* is based upon examination of 1132 animals trapped along the outer fringing reef of Palau, W. Caroline Islands, during 1977-1979 (Figure 1). The holotype (USNM 730549) is a mature male weighing 1450 g (body plus shell weight in air) with a shell diameter of 216 mm. For typological reference, data on additional paratypes and topotypes are tabulated in Table 1.

The new species is unusually large in comparison to other species of *Nautilus* (see SAUNDERS, 1981). Mature shells of 375 animals trapped in 1977 ranged from 180 to 226 mm diameter, with a mean diameter of 204 mm; the weight (body plus shell) of 268 mature animals ranged from 950 to 1800 g, with a mean of 1308 (SAUNDERS & SPINOSA, 1978).

Sexual dimorphism is prominent in mature animals, expressed as differences in overall size and proportions. The mean diameter and total weight of 213 mature males reported by SAUNDERS & SPINOSA (*ibid.*) was 209 mm (N=213) and 1426 g (N=138) respectively, in contrast to 198 mm (N=89) and 1157 g (N=81) for mature females. In addition, mature males exhibit a broader aperture (mean 99 mm) than females (mean 91 mm), as a result of constriction of the female aperture as maximum size is approached, at approximately 180 mm diameter (Figures 8, 9). This does not occur in the males, which



require a larger body chamber to accommodate the large accessory reproductive organ, the spadix. It is notable that males substantially outnumber females; of 1 132 animals trapped and sexed, 817, or 72%, were male.

As in *Nautilus pompilius*, the umbilicus of *N. belauensis* is small (approximately 5% of the shell diameter) and, with only rare exceptions, it is filled by a calcareous deposit, the callus. Deposition of the callus begins at approximately 100 mm diameter in the Palauan form and it completely closes the umbilicus by 110 mm diameter. The total number of septa in the shell of mature animals varies, but there are commonly 35 (Table 2). As in other species of *Nautilus*, septal approximation (closer spacing of adjacent septa) occurs between the 7<sup>th</sup> and 8<sup>th</sup> septa, in association with the nepionic constriction, as well as between the final two septa in many specimens. In addition, the final septum may be thicker than previous septa. Maximum growth is marked by thickening of the aperture, a white body chamber that lacks color banding, deposition of a black layer along the apertural margin, accentuation of the hyponomic and ocular sinuses, and elongation of the body chamber. These features characterize maturity in the sense that maximum growth has been achieved, but their relationship to reproductive maturity is unknown; they may, in fact, be gerontic characters. Approximately 80% of specimens of *N. belauensis* trapped in Palau were mature; by contrast, very young animals (less than 100 mm diameter) were extremely rare: only 5% were less than 160 mm diameter (78% of the mean diameter, 204 mm) and the smallest of 1 132 animals trapped measured 85 mm shell diameter (111 g weight in air).

(← adjacent column)

Figure 1

Location map showing principal *Nautilus* trapping sites (Mutremdiu Point and Ngemelis Island) in Palau, West Caroline Islands

### Explanation of Figure 3

*Nautilus belauensis* spec. nov., Palau, West Caroline Islands

Mature female, trapped May, 1977, ca. 200 m depth, Mutremdiu Point, Palau; photographed in shallow water

approx.  $\times \frac{1}{4}$



Figure 3



Table 1

Data from type specimens of *Nautilus belauensis* Saunders, spec. nov.

	Spec. No.	Locality	D	U	Wm	Wt	Mat	Sex	Miscl.
fig'd	paratype USNM 730672	Palau, W. Caroline Is.	101.7	7*	52.4	170	I	—	umbilicus open
fig'd	paratype USNM 730673	Palau, W. Caroline Is.	211.4	9*	96.5	1462	IBM	M	umbilicus open
fig'd	holotype USNM 730549	Palau, W. Caroline Is.	216	—	103.5	1449	M	M	
	topotype USNM 730674	Palau, W. Caroline Is.	149.7	—	72.4	455	I	F	
	topotype USNM 730534	Palau, W. Caroline Is.	218.8	—	101.7	1543	M	M	
	topotype USNM 730535	Palau, W. Caroline Is.	208.8	—	100	1421	I	M	
	topotype USNM 730536	Palau, W. Caroline Is.	209.5	—	99.8	1443	M	M	
	topotype USNM 730537	Palau, W. Caroline Is.	198.2	—	87.2	—	M	F	
fig'd	topotype USNM 730675	Palau, W. Caroline Is.	215.8	—	106.4	—	M	M	white umbilicus
fig'd	paratype USNM 730676	Palau, W. Caroline Is.	190.	—	85.1	—	M	F	
fig'd	paratype USNM 730546	Palau, W. Caroline Is.	205.3	—	95.5	1238	IBM	F	

D, maximum shell diameter; U, umbilical diameter measured across umbilical shoulders; Wm, maximum width at aperture (all measurements in mm); Wt, weight (gms) of body plus shell in air at time of capture; Mat animal maturity, classed as: M, fully mature, displays all mature characteristics including blackened and thickened aperture, deepened ocular, hyponomic sinuses, white body chamber; MB, barely mature, with aperture barely blackened and thickened; IBM, submature, without apertural blackening or thickening, but with full size, white body chamber; I, immature, shows no characteristics of maturity (for details see Saunders and Spinoso, 1978). Sex determined by sexing of live animals. Asterisked measurements are approximate.

Table 2

Data on size, number of septa, septal thickening and approximation in sectioned shells of mature *Nautilus pompilius*, *Nautilus belauensis* sp. nov. and *Nautilus scrobiculatus*

Species	Number	Locality	D	Sex	S	Aprx	Thk
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	168.2	—	38	7/8, 14/15, 37/38	38
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	172*	—	34	7/8	34
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	146	—	29	7/8	28/29
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	172.4	—	34	7/8	34
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	171*	—	35	7/8	35
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	172	—	33	7/8	—
<i>Nautilus pompilius</i> Linnaeus	BMC unnumb.	Philippines?	176*	—	32	7/8	32
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	199.7	F	35	7/8	35
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	215.1	M	35	7/8	34/35
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	219.9	F	35	7/8	34/35
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	214*	M	35	7/8	34/35
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	213*	—	37	7/8	37
<i>Nautilus belauensis</i> sp. nov.	BMC unnumb.	Palau	204.9	F	36	7/8	35/36
<i>Nautilus belauensis</i> sp. nov.	BMC 228	Palau	207.3	M	35	7/8	34/35
<i>Nautilus belauensis</i> sp. nov.	BMC 17	Palau	205.6	M	33	7/8	33
<i>Nautilus scrobiculatus</i> (Lightfoot)	BMC unnumb.	Solomons	192*	—	33	7/8	32/33

D, maximum shell diameter (mm); S, total number of septa at maturity; Aprx, septal approximation, or close spacing between adjacent septa; count begins with first (smallest) septum; Thk, presence of thickened final septum. All specimens fully mature. Asterisked measurements are approximate. BMC prefix indicates collections at Bryn Mawr College.

The shell sculpture of *N. belauensis* is distinctive. In all living species of *Nautilus*, the growth lines are sinuous, reflecting ocular and hyponomic sinuses (Figure 11), but in the Palauan species the shell sculpture includes delicate, longitudinally crenulated ridges that produce a distinctive, concentrically lirated pattern (Figures 5, 7). The lirae are present on all specimens examined (including very young shells). They are most prominently expressed on the ventrolateral portions of the shell and their strength may vary between individuals. This sculpture is known in only one other species of *Nautilus*, *N. scrobiculatus* (see comparison).

The pattern of shell coloration is variable, but characteristically comprises irregular, brown to reddish brown stripes extending from the umbilicus and branching across the flanks. The color bands cover the entire immature shell (Figures 6, 12), but deposition of the bands ceases as maturity is approached, often at approximately the position of the last septum in mature shells. Thus, the final body chamber, or ventral one-half of the mature shell, lacks color bands (presumably a protectively advantageous pattern). In a few specimens, the color bands do not extend to the umbilicus, leaving a white adumbilical region, such as that which has been cited as distinguishing other species, including *Nautilus repertus* and *N. ambiguus* (see SAUNDERS, 1981 for discussion).

Except for the generally larger size, the anatomy of the soft parts appears indistinguishable from *Nautilus pompilius*. In fact, it is curious that no differences in the soft parts of any of the described species of *Nautilus* have been recorded, with the exception of a difference in the hood texture of the single known specimen of *N. scrobiculatus* noted by WILLEY (1902: pl. 78, fig. 3). The jaw apparatus is also indistinguishable, except for its large size, from other species of *Nautilus*; this is a revision of earlier statements to the effect that the jaw of the Palauan *Nautilus* appears to differ from those of *N. pompilius* and *N. macromphalus* (SAUNDERS *et al.*, 1978; and see Discussion).

The radula in mature animals is a formidable structure, measuring approximately 10 mm by 40 mm. As in fossil nautiloids (and in the living species *N. macromphalus* and *N. pompilius*) the radula consists of a series of rows, each comprising 13 elements, including a central rachidian tooth and 4 lateral teeth, 4 attenuate, crescentic marginal teeth and 4 subrectangular marginal support plates (Figure 2; see also SOLEM & RICHARDSON, 1975; SAUNDERS & RICHARDSON, 1979).

**Comparison.** The large size, the lirated shell sculpture and the wide radular teeth of *Nautilus belauensis* are the primary criteria for distinguishing the new species. With the exception of two large specimens from Australia described as *N. repertus* (see IREDALE, 1944) all other *Nautilus* are considerably smaller, ranging from 140 mm diameter for *N. pompilius* from Fiji, and 170 mm diameter for the same species from the Philippines; 160 mm for *N. macromphalus*, and 180 mm for *N. scrobiculatus*. It is notable that the larger size of *N. belauensis* is more than just a product of a longer period of growth, because (a) the total number of septa are similar in both the Palauan (33-37 septa) and Philippine forms (32-38 septa) in spite of their size differences (Table 2), and (b) umbilical closure occurs at a considerably larger size in *N. belauensis* (at approximately 100 mm diameter) than in Philippine *N. pompilius* (at approximately 75 mm diameter). The prominent longitudinal crenulations on the shell of *N. belauensis* are known only in *N. scrobiculatus*, in which they are coarser and occur in combination with a markedly different shell form (see SAUNDERS, 1981, figure 5). Some faint longitudinal sculpture may occur in occasional specimens of *N. pompilius* and in *N. macromphalus*, but it does not approach the strength characterizing *N. belauensis*. Comparison of the radula of the new species indicates that the central rachidian tooth and to a lesser extent the second lateral teeth are wider and

### Explanation of Figures 4 to 9

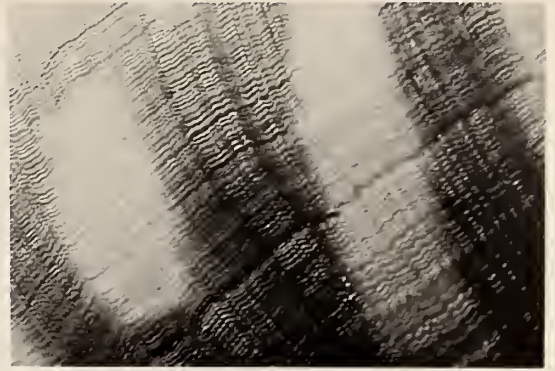
*Nautilus belauensis* spec. nov., Palau, West Caroline Islands

Figure 4: Apertural view of swimming female shown in Figure 3 approx.  $\times \frac{1}{2}$   
 Figure 5: Enlarged view of shell showing longitudinally crenulate shell sculpture (Paratype, USNM 730546)  $\times 3\frac{1}{2}$   
 Figure 6: Shell of young specimen (Paratype, USNM 730672) caught alive, in which umbilical callus had not yet been deposited. Note presence of color bands on entire shell and shallow ocular sinus  $\times \frac{1}{2}$

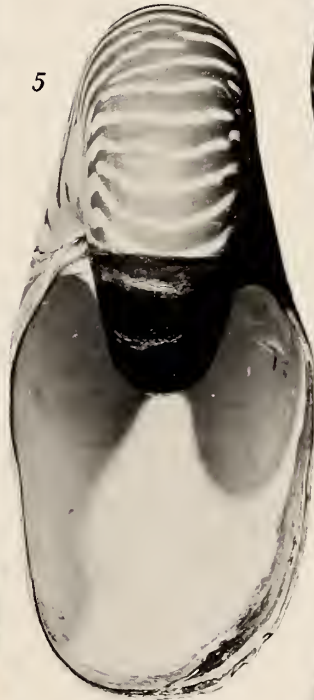
Figures 7, 8: Lateral and apertural views of shell of holotype (USNM 730549), a mature male, trapped July 7, 1977, Mutremdiu Point, Palau. Note absence of color bands on body chamber and accentuated ocular sinus; both are characteristic of mature shells  $\times \frac{1}{2}$   
 Figure 9: Apertural view of mature female (Paratype, USNM 730676)  $\times \frac{1}{2}$



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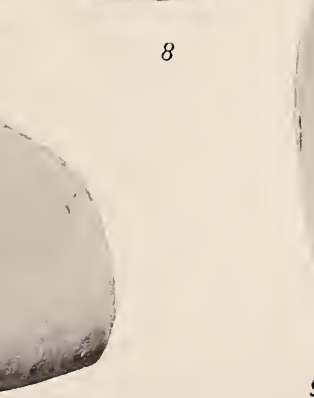
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